

Phosphorus Content of Some Fishes and Shrimp in the Gulf of Mexico

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CONTRIBUTION

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Abstract

The total phosphorus composition was determined for ten species of fish and one species of shrimp found in the coastal and bay waters of Galveston, Texas. The results of the analyses, which were based on the entire animal, were compared with the few similar analyses that have been made on other marine species. Shrimp contained about 1.46% P of dry weight (0.35% of wet weight). Fishes contained 2.43 to 3.81% P of dry weight (0.47 to 0.84% of wet weight). A brief discussion of the biogeochemical phosphorus cycle is included.

Phosphorus is one of the most measured ingredients of sea water. This element in its ionic form as phosphate is vital to the production of plant life, and most marine scientists, therefore, consider it significant as an indicator of productivity. Phosphorus also occurs in particulate and dissolved organic compounds and in organisms. The importance of this element in food has resulted in chemical investigation of marine products. W. O. Atwater (1892) determined the phosphorus composition of many food fish and invertebrates; later data were summarized by Vinogradov (1953). Most of the work was based on specific organs, tissues, or parts, rather than the whole animal. This paper presents the phosphorus content of various fishes and shrimp based on the entire animal. The specimens analyzed included inhabitants of the coastal and bay waters of Galveston, Texas, and an undetermined species of lantern fish (family Myctophidae) taken about 50 miles southwest of the Mississippi Delta.

These data will be useful in three ways: (1) deciding whether chemical composition varies between species, (2) determining the quantities of phosphorus in the biomass of higher organisms, and (3) determining the annual loss of phosphorus from the sea through the harvest of fishery products.

Chemical Analysis

The organic phosphorus in the dried or partially ashed (8 hr at 500–600°C) specimen was converted to inorganic forms by a sulfuric-nitric acid digestion. After digestion the residue was fumed down to about half its volume to reduce a by-product of the digestion reaction, nitrosyl sulfuric acid. This was necessary to prevent interference from the by-product in the subsequent phosphorus analysis. The sample was cooled and a portion of it diluted to the equivalent of about 10,000 ml per gram dried sample weight. Two sets of aliquot samples were prepared for analysis. One contained 1 ml of the diluted specimen mixture and the second, 3 ml. The samples of both sets were diluted to 25 ml with distilled water. The analytical method employed was that described by Robinson and

Thompson (1948). Control samples were prepared from KH_2PO_4 and also from a dried powdered fish mixture of known phosphorus composition. The purpose of the latter was to detect interference due to the nitrosyl sulfuric acid in the samples. Each specimen was analyzed four times. The precision of the average of the four analyses per specimen was estimated to be 0.1 mg P per gram sample weight (dry basis). The analyses are tabulated in Table 1.

TABLE 1
Phosphorus content of certain fishes and shrimp

Species	No. of specimens	Per cent of phosphorus				
		Average weight		Wet weight	Dry weight	
		Wet g	Dry g	Average	Average	Standard deviation
Lanternfish (Family Myctophidae)	34	1.2	0.26	0.82	3.11	0.37
Searobin <i>Prionotus tribulus</i>	12	7.2	1.89	0.84	3.20	0.71
Broad killifish <i>Cyprinodon variegatus</i>	24	1.1	.26	0.70	3.08	0.33
Spot <i>Leiostomus xanthurus</i>	14	35.6	7.94	0.51	2.29*	0.36
8-fingered threadfin <i>Polynemus octonemus</i>	22	4.2	0.78	0.55	3.00	0.70
Catfish <i>Galeichthys felis</i>	10	20.7	4.85	0.82	3.49	0.27
Ling <i>Phycis floridanus</i>	22	46.8	8.99	0.47	2.43	0.24
Anchovy <i>Anchoviella mitchilli</i>	19	.....	0.06	.....	2.91	0.24
Mullet <i>Mugil cephalus</i>	16	20.5	5.10	0.83	3.31	0.49
Mullet <i>Mugil cephalus</i>	15	.....	0.04	.....	2.53	0.25
Menhaden <i>Brevoortia patronus</i>	14	27.0	6.72	0.80	3.39	0.66
Menhaden <i>Brevoortia patronus</i>	19	0.7	0.13	0.76	3.81	0.54
Shrimp—Male <i>Penaeus setiferus</i>	7	22.7	5.41	0.36	1.49	0.09
Shrimp—Female <i>Penaeus setiferus</i>	17	23.7	5.64	0.34	1.41	0.27
Shrimp (sex unknown) <i>Penaeus setiferus</i>	25	.....	1.44	.....	1.47†	0.34

* Phosphorus analyses performed on “ashed” samples.
† Phosphorus analysis of 10 specimens was performed on “ashed” samples.

Discussion

We were not able to find any reference to phosphorus data, based on the entire animal, of the species we analyzed. However, analyses of entire organisms have been reported for other species. Sempolowsky (1889), cited in Atwater (1892), reported phosphorus contents of 0.53 and 0.78%, based on the entire fish, for the haddock (*Melanogrammus aeglefinus*) and the gray gurnet (*Trigla gurnardus*). Weigelt (1891), cited in Vinogradov (1953), reported 0.52–0.56% and 0.45–0.51% (whole weight basis), respectively, for the same species, 0.36% for the sea herring (*Clupea harengus*), 0.57–0.61% for the cod (*Gadus morrhua*), and 0.43% for the anglerfish (*Lophius piscatorius*). We

are aware of only one study of fresh-water fish in which the entire animal was analyzed for phosphorus. McCay *et al.* (1931) in nutritional studies of fresh-water trout (*Salvelinus fontinalis*) reported a range of 0.24–0.55% based on the entire fish.

Milone (1896), cited in Vinogradov (1953), reported a substantial decrease in phosphorus content with size for two species that he analyzed. The phosphorus content of Mediterranean species (*Smaris vulgaris*) was 0.53 and 0.89% (whole weight basis) for large and small specimens, respectively. Similarly, he reported values of 0.34 and 1.10% (whole weight basis) for the surmullet (*Mullis surmuletus*). Analysis of the menhaden (*Brevoortia patronus*) and shrimp (*Penaeus setiferus*) data (Table 1) shows no significant difference in the phosphorus content of large and small specimens. There appears to be a significant difference, however, in the phosphorus content of the two groups of mullet (*Mugil cephalus*).

The higher phosphorus content of fish as compared to shrimp was undoubtedly due to the high phosphate content of bone. The bones of many fish contain up to 65% mineral residue (Roche and Bullinger 1939), the $\text{Ca}_3(\text{PO}_4)_2$ content of which has been reported as high as 94% (Vinogradov 1953). Fish scales from some species also contain large amounts of phosphorus. Carnot (1893) was cited by Vinogradov (1953) as having reported values as high as 98.38% as $\text{Ca}_3(\text{PO}_4)_2$ for the mineral content of certain scales. The phosphorus content of the soft parts of fishes averaged about 0.3% on a whole weight basis (Vinogradov 1953), but variation among species is quite large. Krukenberg (1877) was cited by Vinogradov (1953) as having reported 0.032% for the dogfish (*Acanthias vulgaris*), and Javillier and Cremieu (1928) report 0.93% for the carp (*Cyprinus carpio*). This variation may reflect results based on individual specimens rather than on the mean of a number of fish (Vinogradov, 1953).

Shrimp show (Table 1) little difference in phosphorus content between sexes or size groups. The values shown (1.41–1.49%) are somewhat higher than that of Decapoda, in general, which range from 0.63–1.36% on a dry weight basis (Vinogradov, 1953). Again, we were unable to make a direct comparison with work on *Penaeus setiferus*. Weigelt (1891), cited in Vinogradov (1953), reported a value of 1.27% (dry weight basis) for *Crangus vulgaris*, and Delff (1912), also cited in Vinogradov (1953), reported 1.08% for the same species.

It is not the purpose of this paper to delve into the biogeochemical aspects of phosphorus, other than to mention that the phosphorus content of marine animals constitutes an important source for the return of this element to the land. Hutchinson (1952) stated that based on Clark's (1889) estimate, approximately 13.7 million tons of phosphorus are delivered to the oceans annually. The biogeochemical paths of return are considerably less than this (Hutchinson, 1952), and as a result, phosphorus at the surface of land masses may be decreasing. Hutchinson (1952) stated that the annual return of phosphorus to the land by fisheries of the world, based on an annual catch of 25–30 million tons, is about 60,000 tons. The estimate would assume an average phosphorus value of about 0.25% which is considerably less than the values shown in Table 1. We therefore believe his estimate to be conservative.

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